Technical Memorandum:
Cumulative Impact Analysis
Indicators for Existing Community Conditions Assessment

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1. Introduction

On March 26, 2021, Governor Charlie Baker signed sweeping legislation that will address climate issues and protect environmental justice populations.[1] The legislation requires the Massachusetts Department of Environmental Protection (MassDEP), with input from stakeholders, to propose regulations to include cumulative impact analysis (CIA) for defined categories of air quality permits.

MassDEP is proposing to require a CIA for certain air comprehensive plan approvals for proposed projects located within 1 or 5 miles of an environmental justice population, as defined by the Massachusetts Executive Office of Energy and Environmental Affairs (EEA) 2021 Environmental Justice Policy.[2] The purpose of this technical memorandum is to summarize the indicators to be included and described in the Existing Community Conditions Report, which is required as part of the CIA.

This document provides a description of the indicator evaluation criteria and process, and an overview of all indicators to be included in an Existing Community Conditions Report. An overview of the CIA Process is described in a companion document, the Technical Memorandum: CIA Guidance for Collecting and Presenting Indicators for the Existing Community Conditions Report.

2. Indicator Selection

MassDEP has been tasked to develop a CIA approach for certain air permits. The CIA is a comprehensive and systematic approach to assessing and managing air quality and risks and requires review and consideration of multiple stressors or indicators not previously incorporated into permitting decisions. Stressors are defined as any chemical, physical, biological, socioeconomic, or demographic parameter that may cause adverse impacts to human health. Often, there are no direct measures of these stressors. Indicators can be used to indirectly assess stressors that may cause adverse impacts to human health associated with air pollution and air quality. MassDEP developed a comprehensive list of indictors that were then systematically evaluated for inclusion in the CIA.

2.1 Initial Indicator List

To develop an extensive list of indicators, MassDEP evaluated CIA approaches used in air quality permitting and environmental justice (EJ) screening tools and data developed by other jurisdictions. To develop the initial extensive list of indicators, the indicators were included from the following approaches and tools:

- Existing CIA approaches
  - Minnesota Pollution Control Agency Cumulative Levels and Effects Assessment
  - New Jersey Environmental Justice Law and Proposed Process
  - Massachusetts Environmental Policy Act (MEPA) Interim Protocol for Analysis of Impacts on Environmental Justice Populations

1 Office of Governor Charlie Baker and Lt. Governor Karyn Polito. 2021 “Governor Baker signs Climate Legislation to Reduce Greenhouse Gas Emissions, Protect Environmental Justice Communities.” https://www.mass.gov/news/governor-baker-signs-climate-legislation-to-reduce-greenhouse-gas-emissions-protect-environmental-justice-communities.

2 Available at https://www.mass.gov/service-details/environmental-justice-policy

- Screening tools and data
  - EJScreen (U.S. Environmental Protection Agency)
  - Climate and Economic Justice Screening Tool (White House Council on Environmental Quality)
  - CalEnviroScreen (California Office of Environmental Health Hazard Assessment)
  - Population Level Analysis and Community Estimates (PLACES) (U.S. Center for Disease Control)
- Massachusetts data and tools
  - Massachusetts Department of Public Health (DPH) EJ Tool
  - Massachusetts 2020 Environmental Justice Populations (EEA)
  - Massachusetts Environmental Public Health Tracking (EPHT) Portal
  - Massachusetts Population Health Information Tool (PHIT)
  - Massachusetts Bureau of Geographic Information MassMapper Interactive Map

After reviewing these sources, an initial list of potential indicators was developed. MassDEP presented the list of indicators to stakeholders during the November 16 and November 17, 2021, stakeholder meetings. The goal of the meetings was to present the list of indicators and obtain stakeholder feedback and input on the list. Specifically, we asked the stakeholders to identify any additional indicators that should be evaluated for inclusion in the CIA or any indicators that they felt were not necessary. We also asked for input regarding indicators that they felt were of particular importance for the CIA effort. We received valuable input during these stakeholder meetings and amended the extensive list of indictors to include the feedback received during these meetings.

2.2 Indicator Selection Criteria

From the review of indicators, discussions with Massachusetts experts, and input from stakeholders, there were over 80 indicators on the list.[3] Initially, MassDEP developed five general criteria for evaluating each indicator. These criteria are similar to those used to evaluate indicators for the proposed New Jersey EJ process and CalEnviroScreen. This section describes the initial criteria that we used to conduct the evaluation and refinement of potential indicators as well as additional criteria that were also considered to select indicators to describe existing conditions for the CIA.

2.2.1 Data Availability

Data availability is a key criterion for evaluating indicators. The data for an indicator should be accurate, complete, and accessible to include in a CIA. If data are not consistently available for an indicator or perhaps not available for the entire state, that indicator will be difficult to include in the CIA. During the evaluation process we identified if there were potential data sources available for each indicator. We also considered the likelihood that the data source will be maintained and updated in the future. If multiple data sources were available for an indicator, MassDEP evaluated the potential inclusion of each data set and ultimately we provided best professional judgment on which data set is most suitable to consider for inclusion in the CIA based on the additional screening of that indicator (e.g., MassDEP selected for consideration the data set that was most current or indicator that was at a more refined geographic scale).

[3] See separate spreadsheet developed to identify and screen indicators, including a rationale for whether the indicator was or was not included in the final set of indicators.

2.2.2 Appropriate Geographic Scale

Making sure that the data are at an appropriate geographic scale is an important consideration when evaluating indicators for potential inclusion in the CIA. For example, some of the public health data from the Massachusetts DPH is provided at the community level, which is due primarily to privacy concerns. This geographic scale may not be as granular as we would like when assessing how pollution could affect neighborhoods adjacent to the proposed project. In addition, some of the public health data, such as asthma-related emergency room visits, may include people from outside the area. These issues do not necessarily mean that these data cannot be considered in the CIA, but rather, this may affect how the indicator is included in the CIA; information could be supplemented, for example, with community input.

2.2.3 Appropriate Timeframe

The timeframe covered by the indicator data source may affect whether it is useful to the CIA. Outdated indicator data may not be reflective of the current or future status of the stressor. For example, census tract-level data are available annually; more granular U.S. Census block-level data are only available every 10 years.

During the evaluation process we identified the timeframe of the data source for each indicator described in the text below. We used this information to inform our evaluation.

Applicants and MassDEP will use the most current data published by the source identified in the regulation at the time of the permit application.

2.2.4 Redundancy

Redundancy may impact inclusion of an indicator in the CIA. If two indicators are measuring or evaluating a similar stressor, it may not be necessary to include both in a CIA. In evaluating each indicator, we considered the potential for overlap and double counting among indicators. To the extent possible, we leveraged existing peer-reviewed literature and reports to determine which indicators were redundant, including the literature associated with the development of indicators included in CalEnviroScreen. To inform the redundancy of indicators, MassDEP conducted statistical analysis (i.e., correlations, regressions) to determine if multiple indicators were needed as part of the CIA.

2.2.5 Qualitative or Quantitative

We have identified some indicators that are qualitative, others that are quantitative, and some that can be assessed both quantitatively and qualitatively. Whether an indicator is qualitative or quantitative is not necessarily an evaluation criterion but rather a consideration in terms of how best to use each type of indicator within the CIA framework.

2.2.6 Additional Evaluation Criteria

After beginning the initial evaluation process, MassDEP identified the following additional evaluation criteria to evaluate indicators for inclusion in the CIA for air permitting.

- **Indicator is included in EEA Environmental Justice Policy.** The Massachusetts Executive Office of Energy and Environmental Affairs (EEA) established a statewide Environmental Justice Policy in 2002 and updated it in 2017 and in 2021.[4] The EEA Environmental Justice Policy identifies neighborhoods (e.g., Block Groups) that meet EJ

4 EEA Environmental Justice Policy, 2021: https://www.mass.gov/doc/environmental-justice-policy6242021-update

criteria (minority, low income, and limited English language proficiency). In addition, the policy provides vulnerable health EJ criteria that have been defined as four human health indicators that identify populations with evidence of higher-than-average rates of adverse health outcomes: childhood asthma, heart attack, low birthweight, and childhood blood lead levels. The Massachusetts tools make the EJ and vulnerable health EJ data accessible so that it can be used in inclusive community planning for environmental assessment, and to inform activities such as siting, permitting, MEPA review, and community, health, or climate-related impact assessments. MassDEP considered indicators and data sources that were consistent with the EEA Environmental Justice Policy for inclusion in the CIA for air permitting.

- **Indicator and data source is available through Massachusetts-specific online or mapping tools.** MassDEP considered all the Massachusetts-specific data sources for indicators, including DPH EJ Tool, EEA EJ Populations Tool, Massachusetts EPHT Portal, Massachusetts PHIT, MassGIS MassMapper, MassROUTES, Climate Resilience Design Standards Tool (RMAT), and others. In addition, indicators or data sources that were recommended in the MEPA Interim Protocol for Analysis of Project Impacts on Environmental Justice Populations were considered in the indicator screening process. If multiple data sources were available, MassDEP preferred to use Massachusetts-specific data sources if it met data quality and availability and other evaluation criteria.

- **Indicator is included in a number of other EJ screening tools or approaches.** MassDEP considered if the indicator is included in other state or federal EJ screening or relevant cumulative impact tools. Rigorous statistical analyses have been completed in the development of a number of these screening tools and methods that were considered in the evaluation of indicators. For example, research and literature in the development and validation of indicators for CalEnviroScreen used principal component analyses to evaluate the associations and factor loadings on disease burden. In essence, the research has identified the most relevant indicators to include in the EJ screening tools as well as indicators that may not be statistically significant indicators (e.g., redundant).

- **Literature review and relevance to air pollution.** To further evaluate some of the indicators, MassDEP conducted a literature review to determine the appropriateness and relevance of that indicator for inclusion in the CIA to assess a community’s background exposures, sensitivity, and vulnerability to air pollution. For example, socioeconomic and demographic indicators should represent factors known to influence vulnerability to disease associated with air pollution. A growing body of literature provides evidence of the heightened vulnerability of people of color and lower socioeconomic status to environmental pollutants. Health indicators were also evaluated based on their association with air pollution. Some health indicators are also relevant to issues that may be potentially actionable by MassDEP through the reduction of pollution burden in vulnerable populations, such as asthma. Selected health indicators can serve as a measure of disproportionate impacts in a community from a variety of stressors (as in premature mortality), as measures of potential sensitivity to air pollutants, as well as important baseline measures that may be affected by additional air pollution, for example, chronic obstructive pulmonary disease.

3. Overview of Indicators

Table 1 summarizes 33 indicators that are proposed to be included and evaluated as part of the CIA Existing Community Conditions Report. The indicators are grouped into two broad categories: (1) pollution burden and (2) population characteristics and vulnerabilities. Pollution burden represents potential exposures to pollutants and the adverse environmental conditions that could present health impacts and exposures to people. Within the pollution burden category, there are two types of indicators: (1) air quality/climate, and (2) nearby regulated facilities. **Air quality** includes indicators to identify current and existing air emissions and pollution conditions. An indicator assessing the prevalence of impervious surfaces is included in the air quality/climate category because physical or built environmental conditions can affect the impacts of air pollution through increased heat. Proximity to **nearby regulated facilities** can be an indicator of environmental degradation or potential contaminant exposure which may result in harmful impacts to the ecosystem and people who live near these sites. Living in an environmentally degraded community can lead to stress, which may affect human health. The mere presence of a contaminated site or facility emitting pollution can have tangible impacts on a community, even if actual environmental degradation cannot be documented.[5] These sites or facilities can also contribute to perceptions of a community being undesirable or even unsafe.

Population characteristics and vulnerabilities include indicators in three categories: (1) socioeconomic factors, (2) health, and (3) sensitive receptors. **Socioeconomic factors** are community characteristics that result in increased vulnerability to pollutants, including those indicators included in the EEA Environmental Justice Policy.[6] A growing body of literature provides evidence of the heightened vulnerability of people of color and those of lower socioeconomic status to air and environmental pollutants. **Health indicators** describe populations with physiological conditions that could have increased vulnerability to air emissions and other pollutants, such as those with asthma or cardiovascular disease. **Sensitive receptors** are areas where the occupants are more susceptible to the adverse effects of air pollution, such as children in schools or elder people in long-term care facilities.

5 California Office of Environmental Health Hazard Assessment and California Environmental Protection Agency CalEnviroScreen 4.0 documentation provides additional information: https://oehha.ca.gov/media/downloads/calenviroscreen/report/calenviroscreen40reportf2021.pdf

6 EEA Environmental Justice Policy, 2021: https://www.mass.gov/doc/environmental-justice-policy6242021-update

Table 1. CIA Indicators for Evaluation in the Existing Community Conditions Report.

Pollution Burden	Population Characteristics and Vulnerabilities
Air Quality/Climate • Fine particles that are less than 2.5 micrometers in diameter ($PM_{2.5}$) • Ozone • Diesel particulate matter (PM) • Air toxics cancer risk • Air toxics respiratory hazard index • Traffic volume and proximity • Impervious surface **Nearby Regulated Facilities** • Facilities with MassDEP air permits • Facilities reporting under the EPA Toxics Release Inventory (TRI) program • Facilities reporting under the Toxics Use Reduction Act (TURA) (large quantity toxics users) • Hazardous waste treatment, storage, and disposal facilities • Solid waste diversion and disposal facilities • Large quantity hazardous waste generators • Wastewater treatment plants • Airports • Freight rail yards • Port facilities	**Socioeconomic Factors** • Poverty/low-income • Communities of color • English language isolation • Young (< 5 years old) • Older (> 65 years old) **Health Conditions** • Asthma prevalence in schools • Elevated blood lead levels • Low birth weight • Chronic obstructive pulmonary disease • Coronary heart disease • Premature mortality **Sensitive Receptors** • Schools (K-12) • Child/Day care and pre-schools • Long-term care residences • Public and subsidized housing • Prisons

4. Description of Indicators

This section provides a description of each of the indicators to be included in an Existing Community Conditions Report as part of the CIA, specifically a general description of the indicator, indicator measurement and units, data source for the indicator, rationale for including the indicator, and a reference section.

4.1 Socioeconomic and Demographic Factors

4.1.1 Low Income

General Description

The EEA Environmental Justice Policy uses three socioeconomic indicators to define EJ populations or neighborhoods, and one of these indicators is a measure of income. Low-income populations are defined in the policy as populations in census block groups with a median household income at or below 65 percent of the statewide median household income for Massachusetts (EEA 2021).

Indicator Measurement and Units

Annual median household income for a census block group as a percentage of the statewide median household income. EEA classifies block groups with median household income that is at or below 65 percent of the statewide median household income as EJ populations (EEA 2021).

Data Source

- EEA's Environmental Justice Map Viewer. https://mass-eoeea.maps.arcgis.com/apps/MapSeries/index.html?appid=535e4419dc0545be980545a0eeaf9b53.
- Data for the EEA's map were obtained from: https://www.mass.gov/info-details/massgis-data-2020-environmental-justice-populations
- Original data from U.S. Census American Community Survey (ACS), 5-year estimates. Current ACS data are 2015-2019.

Rationale

Low income or poverty is a social determinant of health; low-income populations can be vulnerable to air pollution for a number of reasons. Low-income individuals may experience high levels of chronic stress that can make them more susceptible to illness and reduce their ability to cope with exposure to environmental hazards such as air pollution (Gee and Payne-Sturges 2004; Cushing et al. 2015). Additionally, low-income neighborhoods can have reduced access to resources such as nutritious foods and medical care needed to prevent and manage the health impacts of pollution.

Some studies have found that the effect of air pollution on adverse health outcomes is worse for residents of low-income communities compared with higher income communities. A study of traffic pollution exposure and birth outcomes in eastern Massachusetts found that the detrimental impact of increased exposure varied according to the median household income where the mother lived; mothers from lower income neighborhoods experience more adverse birth outcomes than those from higher income neighborhoods (Zeka et al. 2008). A study of PM_{10} exposure and socioeconomic status in Rome, Italy, found that PM_{10} exposure was more strongly associated with mortality for low-income individuals than for higher income individuals (Forastiere et al. 2007). A study on the role of neighborhood income and air pollution on respiratory hospitalizations for several Canadian cities found that hospitalizations are higher with air pollution in communities with low-income levels than in communities with higher income levels (Cakmak et al. 2010).

Exposure to air pollutants is also typically higher for low-income populations than for other income levels. In Massachusetts, concentrations of the air pollutants $PM_{2.5}$ and NO_2 are highest for populations with incomes less than $20,000 per year, compared with other income groups (Rosofsky et al. 2018). In California, exposure to pesticides, ozone, cleanup sites, solid waste, and diesel PM is disproportionately high for zip codes with higher poverty rates compared to those with lower poverty rates (Cushing et al. 2015).

In addition, across the United States, low-income individuals are most likely to live in areas projected to experience the worst effects of climate change, including air quality impacts and extreme heat exposure (U.S. EPA 2021). People who are low income or with no high school diploma are more likely to live in areas predicted to experience higher labor hours lost due to heat and have a greater number of asthma diagnoses resulting from increased particulate matter compared with higher income populations (U.S. EPA 2021).

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U.S. EPA (U.S. Environmental Protection Agency). 2021. Climate Change and Social Vulnerability in the United States: A Focus on Six Impacts. U.S. Environmental Protection Agency, EPA 430-R-21-003.

Zeka, A., Melly, S.J., Schwartz, J. 2008. The effects of socioeconomic status and indices of physical environment on reduced birth weight and preterm births in Eastern Massachusetts. *Environ Health* 7:60.

4.1.2 Minority (Communities of Color)

General Description

The EEA Environmental Justice Policy uses three socioeconomic indicators to define EJ populations or neighborhoods, and one of these indicators is a measure of minority populations or populations of color. Populations of color or minority populations refer to individuals who identify as Latino/Hispanic, Black/African American, Asian, Indigenous, or "who otherwise identify as non-white" (EEA 2021).

Indicator Measurement and Units

The percent of the block group population that identifies as Hispanic or Latino ethnicity, and/or races other than White. The EEA Environmental Justice Policy defines environmental justice neighborhoods as block groups where minorities comprise:

- Forty percent or more of the population or
- Twenty-five percent or more of the population is minority when the median household income of the municipality in which the neighborhood (block group) is located does not exceed 150 percent of the statewide median household income.

Data Source

- EEA's Environmental Justice Map Viewer. https://mass-eoeea.maps.arcgis.com/apps/MapSeries/index.html?appid=535e4419dc0545be980545a0eeaf9b53.
- This data were obtained from: https://www.mass.gov/info-details/massgis-data-2020-environmental-justice-populations
- Original data from U.S. Census American Community Survey (ACS), 5-year estimates. Current ACS data are 2015-2019.

Rationale

Due to historical and systemic racism, environmental hazards and pollution are often located near minority populations (NAACP and CATF 2017; Patnaik et al. 2020). Differential exposure to environmental hazards and reduced access to health resources of disadvantaged populations, including people of color, can be operationalized through segregation and local zoning and planning (Wilson 2009). California's environmental risk screening tool, CalEnviroScreen, was used to evaluate the proximity of minority populations to pollutions sources. The study found that living in one of the 10 percent most pollution-affected communities is significantly higher for non-White people than for White people with regard to pesticide use, toxic releases, clean-up sites, hazardous waste, diesel PM, groundwater threats, traffic density, solid waste, ground-level ozone, and impaired water bodies (Cushing et al. 2015).

Modeled exposure to $PM_{2.5}$ from transportation found racial and ethnic disparities in exposure. A study found that Asian, African American, and Latino residents experience disproportionately more exposure, while White residents experience disproportionately less than would be proportional for each population group (Union of Concerned Scientists 2019). A study of ambient air pollution for all census block groups in Massachusetts also found similar inequities.

It found that concentrations of the air pollutant $PM_{2.5}$ are highest for non-Hispanic Black populations, and concentrations of NO_2 are highest for Hispanic populations, compared with other racial and ethnic groups (Rosofsky et al. 2018).

In addition, across the United States, minorities are most likely to live in areas projected to see the worst effects of climate change, including air quality impacts and extreme heat exposure. People who are Black or African American are disproportionately more likely to live in areas that experience the largest increase in respiratory problems such as asthma from particulate matter pollution compared with other racial and ethnic groups (U.S. EPA 2021). In addition to vulnerabilities specific to race and ethnicity, communities of color are also often lower income, leading to additional vulnerabilities as described in the “Low Income” indicator description and rationale above (APA 2017).

The EEA Environmental Justice Policy defines EJ neighborhoods as block groups where “minorities comprise 40 [percent] or more of the population”, or where “minorities comprise 25 [percent] or more of the population and the annual median household income of the municipality in which the neighborhood [block group] is located does not exceed 150 [percent] of the statewide annual median household income” (EEA 2021).

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4.1.3 English Language Proficiency

General Description

The EEA Environmental Justice Policy uses three socioeconomic indicators to define EJ populations or neighborhoods, and one of these indicators is a measure of English language proficiency. Households lack English language proficiency if they have identified English Language Isolation on federal census forms, or they identify as speaking English less than "very well" (EEA 2021).

Indicator Measurement and Units

The percent of the block group households that lacks English language proficiency. The EEA Environmental Justice Policy defines EJ neighborhoods as block groups where the percent of households in block group that have identified English Language Isolation on federal census forms, or they identify as speaking English less than "very well". The EEA Environmental Justice Policy defines EJ neighborhoods as census block groups that have more than 25 percent of the population with limited English language proficiency (EEA 2021).

Data Source

- EEA's Environmental Justice Map Viewer https://mass-eoeea.maps.arcgis.com/apps/MapSeries/index.html?appid=535e4419dc0545be980545a0eeaf9b53.
- This data were obtained from: https://www.mass.gov/info-details/massgis-data-2020-environmental-justice-populations
- Original data from U.S. Census American Community Survey (ACS), 5-year estimates. Current ACS data are 2015-2019.

Rationale

Individuals with limited English proficiency are more likely to experience disproportionate exposure to air pollutants. A study of children exposed to hazardous pollutants from roadways near their homes found that children from non-English-speaking households experienced more exposure than children from English-speaking households (Rubio and Grineski 2021). A study of Harris County, Texas residents and cancer risk from hazardous roadway pollutants found that individuals with limited English proficiency disproportionately lived in high-cancer-risk neighborhoods (Loustaunau and Chakraborty 2019).

Having limited ability to speak English can affect the ability to communicate with healthcare providers and access necessary care, resulting in higher risk of poor health outcomes than for English speakers (Sentell and Braun 2012). Individuals with limited English proficiency are also likely to have limited capacity to find and understand health information that would allow them to make suitable decisions related to their health, also leading to poor health outcomes (Sentell and Braun 2012). Compared to those who speak only English, individuals with limited English proficiency and their children are less likely to have health insurance (Derose et al. 2007). Furthermore, limited English proficiency can hamper the ability of individuals to turn knowledge of environmental health threats into actions such as reporting a concern to government officials or seeing a doctor when concerned about air quality related illnesses (Covert et al. 2020).

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4.1.4 Children and Elderly Persons

General Description

Children are often more vulnerable to pollutants than adults due to differences in behavior and biology, which can lead to greater exposure and/or unique windows of susceptibility during development (U.S. EPA 2022). Research has shown that some people, including children and older adults, are more susceptible than others to air pollutants. Young children under 5 years old are particularly vulnerable to the negative health impacts of exposure to air pollution, with respiratory issues such as asthma being a major concern (U.S. EPA 2018). Older adults are also more vulnerable to pollution exposure effects than most younger adults, as pollution exposure can exacerbate existing health issues in older adults.

Indicator Measurement and Units

These indicators will be measured through the percent of individuals under age 5 years and over age 65 years in a block group and the state percentiles for that block group.

Data Source

- Data accessed through EJScreen, Socioeconomic Indicators (https://ejscreen.epa.gov/mapper/)
- Original data from the U.S. Census American Community Survey (ACS), 5-year estimates. Current ACS data are 2015-2019.

Rationale

Children are vulnerable to pollution, and air pollution specifically, since their lungs are growing, and they breathe more than adults relative to their size (Kulkarni and Grigg 2008). Air pollution has been correlated with asthma emergency department visits, asthma hospitalizations, asthma exacerbation and increased use of medication, missed school days, cough, and mortality due to lower respiratory infections in children (Alhanti et al. 2016; Kulkarni and Grigg 2008; Ko et al. 2007; Lelieveld et al. 2018).

Older adults are also sensitive and susceptible to exposure to air pollution, often due to the presence of disease and comorbidity (simultaneous presence of two or more diseases) in older adults. Ageing is a continuous process of progressive decline of the body's function leading to increased vulnerability, frailty, and sensitivity of elderly people; in this century, a major epidemiological trend is the rise of chronic diseases that affect more elderly than younger people (Simoni 2015). Studies have shown an association between long-term exposure to air pollution and premature death (Piazza 2018). In addition, older adults have been found to have an increased risk of dying after intermittent exposure to elevated levels of air pollution, suggesting that even short-term exposures to air pollution may have an impact on the health of older adults (Piazza 2018; Di et al. 2017; Simoni et al. 2015).

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4.2 Health Conditions

4.2.1 Asthma Prevalence in Schools

General Description

Asthma is a condition that affects the airways to the lungs and can cause difficulty breathing, coughing, wheezing, and chest tightness. Asthma is a common chronic disease in children and one of the leading causes of school absenteeism (CDC 2022). Asthma most commonly begins in childhood but can also begin in adulthood. CDC estimates that in 2019, 8% of adults and 7% of children in the United States had asthma (CDC 2021a).

Indicator Measurement and Units

Pediatric asthma prevalence is measured per 100 students in public and private schools, kindergarten through 8th grade, averaged over a period of three school years. MassDEP determined which schools were in or within ½ mile of an EJ block group and selected the maximum prevalence where there were multiple schools identified and assigned the pediatric asthma prevalence to the EJ block group.

Data Source

Pediatric asthma prevalence per 100 students kindergarten through 8th grade are available in the Massachusetts Environmental Public Health Tracking tool at the school level by community from 2009 to 2017. Data collected by the Massachusetts Center for Health Information and Analysis. MassDEP will publish the 3-year pediatric asthma prevalence for each EJ block group for use in CIA.

Rationale

The causes of asthma are not well understood, but research has established that exposure to air pollution and particulates can trigger asthma symptoms. Access to high-quality care and scheduled doctor visits are important to manage asthma (Mass DPH 2022). Severe or uncontrolled cases of asthma may lead to increased rates of emergency department visits. Asthma prevalence and emergency department visits can be an economic burden for individuals and communities; direct costs include those associated with hospitalizations and treatments, and indirect costs include those resulting from a loss of work and school days (Bahadori et al. 2009).

The prevalence of asthma in Massachusetts is higher than the national prevalence rate. An estimated 10.7% of Massachusetts adults had asthma in 2020 compared to 8.4% across the United States (CDC 2021a; CDC 2021b). An estimated 12.1% of Massachusetts children enrolled in kindergarten to eighth grade in 2016 and 2017 had asthma compared to 5.8% of all children under 18 years of age in the United States in 2020 (Mass DPH 2022; CDC 2021a). In Massachusetts, asthma prevalence is higher among adults and children in lower income households, Black non-Hispanic adults, Black non-Hispanic children, and Hispanic children (Commonwealth of Massachusetts 2022).

People with asthma are more sensitive to air pollution than people who do not have asthma. Exposure to air pollutants can trigger asthma symptoms and exacerbate existing asthma, and exposure may even be associated with the onset of asthma (Guarnieri and Balmes 2014). School age children with asthma are particularly susceptible to air pollution. Due to underdeveloped respiratory and immune systems and increased time spent outdoors, children are more likely to be hospitalized for asthma in response to air pollution exposure (Alhanti et al. 2016).

The EEA Environmental Justice Policy recognizes municipalities with a 5-year average rate of emergency department visits for childhood asthma of at least 110% of the state rate as Vulnerable Health EJ Populations (EEA 2021). The Policy includes childhood asthma as an indicator because people of color and low-income individuals experience increased exposure to asthma triggers that can exacerbate asthma, leading to a negative impact on overall health and wellbeing (Massachusetts DPH 2022). Black, non-Hispanic children are more likely to visit the emergency department for asthma than White, non-Hispanic children (Massachusetts DPH 2022).

Asthma is an indicator commonly used in other EJ assessment tools including California's CalEnviroScreen and EPA's EJScreen. Pediatric asthma prevalence in schools provides information on susceptible populations in schools near a proposed project.

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4.2.2 Coronary Heart Disease

General Description

Coronary heart disease is the leading cause of death in the United States. The disease refers to a number of conditions that alter the structure and performance of the heart. Coronary heart disease can lead to heart attacks or cardiac arrest. An estimated 805,000 people in the United States have a heart attack every year, with 200,000 being recurrent attacks (Virani et al. 2021).

Indicator Measurement and Units

Coronary heart disease is measured among adults aged 18 years or older as the crude prevalence (percentage) at the census tract level. This indicator is self-reported from respondents aged 18 years or older who report ever having been told by a doctor, nurse, or other health professional that they had angina or coronary heart disease as part of the Centers for Disease Control and Prevention (CDC) Behavioral Risk Factor Surveillance System telephone survey.

Data Source

Prevalence estimates for coronary heart disease for each census tract are available in the CDC PLACES database. The current 2021 release includes data from the 2019 survey.

Rationale

Exposure to air pollutants may increase the risk of a heart attack (Cox 2017). There is evidence that short-term exposure to air pollution could increase the risk of cardiovascular mortality following a heart attack, and long-term exposure may lead to premature death for people who have previously had a heart attack (Bai et al. 2019; Liao et al. 2021; Liu et al. 2021; Olaniyan et al. 2022). Air pollution exposure also increases the risk of death after a heart attack. Coronary heart disease and heart attacks can lead to disability, decreased quality of life, and premature death (Massachusetts DPH 2022a).

The elderly, people with pre-existing cardiovascular conditions, and those living in poorer communities are especially at risk of heart attacks. Individuals living in lower socioeconomic status neighborhoods are more likely to experience negative outcomes following a heart attack such as death and major bleeding and experience a lower quality of care following discharge from the hospital (Virani et al. 2021). The Multi-Ethnic Study of Atherosclerosis Air Pollution Study (MESA Air) found a direct link between older individuals with long-term exposure to air pollution and increased risk of heart attacks due to the accelerated buildup of calcium in their arteries (Kaufman et al. 2016).

The EEA Environmental Justice Policy recognizes municipalities with a 5-year average rate of hospitalizations for heart attacks of at least 110% of the state rate as Vulnerable Health EJ Populations (EEA 2021). The policy includes heart attack as an indicator because populations living in EJ communities experience higher rates of hospitalizations for heart attack than other populations (Massachusetts DPH 2022b). Heart disease is also considered an indicator of an EJ community in CalEnviroScreen which includes the indicator cardiovascular disease as measured by heart attack emergency department visits.

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4.2.3 Elevated Blood Lead Levels

Description

Lead poisoning is caused by ingesting or breathing lead, and children aged 9 months to 6 years are most at risk for exposure to lead. The main source of exposure to lead for children in Massachusetts is lead paint in older housing. Massachusetts has the 3rd oldest housing stock in the United States (Massachusetts DPH 2021).

Indicator Measurement and Units

Massachusetts DPH considers blood lead levels elevated if they are greater than or equal to 5 µg/dL. Elevated blood lead levels are measured as the 3-year average annual prevalence of elevated blood lead levels per 1,000 children aged 9 to 47 months in each census tract. Data for some tracts is suppressed to protect privacy due to low sample size, resulting in no data for approximately 48% of census tracts in the state.

Data Source

The 3-year annual average of elevated blood lead level (≥5 µg/dL) prevalence per 1,000 children aged 9 to 47 months is available from MassDEP for census tracts. Data is provided by DPH as collected by the Massachusetts Childhood Blood Lead Prevention Program. The most recent data are from 2017-2020.

Rationale

Childhood exposure to even low levels of lead can lead to negative impacts on rates of growth and development, damage the brain, kidneys, nervous system, hearing and speech, and cause learning and behavior problems (Massachusetts DPH 2022a). CDC recommends 5 µg/dL as the reference blood lead level at which public health actions should be initiated. In 2020, 1,880 children (1.3%) in Massachusetts were estimated to have blood lead levels of at least 5 µg/dL (Massachusetts DPH 2021).

The EEA Environmental Justice Policy recognizes neighborhoods with a 5-year average prevalence of confirmed elevated childhood (ages 9 to 47 months) blood lead levels of at least 110% of the state prevalence as Vulnerable Health EJ Populations (EEA 2021). The Policy includes childhood blood lead levels because low income and minority communities experience disproportionate exposures to lead and can cause irreversible physical and neurological damage (Massachusetts DPH 2022b). Children living in low-income communities are more likely to have elevated blood lead levels than those living in high income communities, and minority children are more likely than White children to have lead poisoning (Massachusetts DPH 2021). Children living in EJ communities may also be more vulnerable to the effects of lead exposure (Bellinger 2008). Lead exposure is an important factor in social determinants of health since it has been associated with school performance, unemployment, crime, violence, and incarceration (Massachusetts DPH 2021).

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4.2.4 Low Birth Weight

Description

Low birth weight infants are those born weighing less than 2,500 grams.

Indicator Measurement and Units

Low birth weight is measured as the 5-year average low birth weight rate per 1,000 singleton, full-term births in each census tract. Data for some tracts is suppressed due to low sample size resulting in no data for approximately 52% of census tracts in the state.

Data Source

The five-year annual average low birth weight rate per 1,000 for 2011 to 2015 is available in the Massachusetts DPH Environmental Justice Tool for census tracts in Massachusetts. Data are collected by Massachusetts Registry of Vital Records and Statistics.

Rationale

An estimated 297,604 babies in the United States (8.24%) were born low birth weight in 2020 (CDC 2022). Low birth weight is associated with infant mortality and health risks in childhood and later in life (Knop et al. 2018; McIntire et al. 1999). Exposure to air pollutants can increase the risk of delivering a low-birth-weight infant (Fleisher et al. 2014; Mass DPH 2022).

Air pollution exposure during pregnancy is associated with adverse birth outcomes and can increase the risk of low birth weight (Mass DPH 2022; Enders et al. 2019; Fleischer et al. 2014; Heo et al. 2019). Environmental contamination tends to be higher in low-income communities and communities of color, and women of color or low income have a higher risk of delivering low birth weight babies (Mass DPH 2022; Heo et al. 2019; Enders et al. 2019). Women who have experienced racial discrimination are also more likely to deliver low birth weight infants due to increased stress and differential access to resources such as healthcare throughout their lives (Alhusen et al 2016).

The EEA Environmental Justice Policy recognizes neighborhoods with a 5-year average low birth weight rate of at least 110% of the state prevalence as Vulnerable Health EJ Populations (EEA 2021). The Policy includes low birth weight as an indicator because health disparities caused by low birth weight, including cognitive disorders and higher rates of chronic diseases in adulthood, can be prevented through targeted outreach and interventions to women in EJ communities (Massachusetts DPH 2022). Low birth weight is also an indicator of sensitive populations in CalEnviroScreen.

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4.2.5 Premature Mortality

General Description

Premature mortality is death before the average age of death in a defined population. The average age of death in the United States is approximately 75 years old (Arias and Xu 2020). Premature mortality is used as a metric of overall population health.

Indicator Measurement and Units

Premature mortality is measured as deaths per 100,000 before the age of 75 years. Data are averaged over a period of 5 years at the census tract level.

Data Source

Premature deaths are tabulated by the Massachusetts Department of Public Health Registry of Vital Records and Statistics for each block group. MassDEP calculated the deaths for each census tract for each year, averaged the deaths for the 5-year period, and calculated the rate from the most recent ACS population. Data for 23 tracts were not present due to no reported population or suppressed data due to low sample size. Where data for some years exist for a tract but not others, the average was estimated from the data available. MassDEP will post premature mortality for census tracts on its webpage. The most recent data available are for 2015-2019 and are updated annually. Massachusetts DPH publishes premature mortality for the state and by municipality in its Annual Massachusetts Death Report.

Rationale

The cumulative burden of multiple stressors throughout life can result in disparities in premature mortality rates. Higher mortality among Blacks compared to Whites has been attributed to a higher allostatic load, or wear and tear on the body that can result from exposure to chronic stress (Duru et al. 2012; Guidi et al. 2021). Chronic stressors that contribute to allostatic load are caused by a number of social factors including exposure to institutionalized racism, neighborhood violence, and substandard housing. Independent of health behaviors such as smoking and physical activity, and socioeconomic status, allostatic load was found to partially explain the disparity in mortality (Duru et al. 2012).

The relationship between exposure to air pollution and mortality has been established in multiple studies. In the largest study conducted to date, risk of death was found to increase with increases in air pollution exposure (Di et al. 2017). Moreover, mortality rates in relation to air pollution have been found to vary based on community characteristics. These characteristics included percentage of minorities, unemployment rate, and use of public transportation (Bell and Dominici 2008).

Premature mortality is included as an indicator because it represents the overall health of a community and can also reflect community-related stressors and existing exposures to air pollution. A similar indicator, low life expectancy, is also included in EJSCREEN.

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4.2.6 Chronic Obstructive Pulmonary Disease

General Description

Chronic obstructive pulmonary disease (COPD) is an inflammatory lung disease that obstructs airflow and makes it difficult to breath. COPD includes the conditions emphysema and chronic bronchitis, which can occur together in individuals with COPD and can vary in severity. In 2020, approximately 5.6% of adults or about 15 million people were diagnosed with COPD in the United States. COPD is the fourth most common cause of death and can increase the risk of developing other diseases such as coronary heart disease and lung cancer (NIH 2022).

Indicator Measurement and Units

COPD is measured among adults aged 18 years or older as the crude prevalence (percentage) at the census tract level. This indicator is self-reported from respondents aged 18 years or older who report ever having been told by a doctor, nurse, or other health professional that they had COPD, emphysema, or chronic bronchitis as part of the CDC Behavioral Risk Factor Surveillance System telephone survey.

Data Source

Prevalence estimates for COPD are available in the CDC PLACES database.

Rationale

COPD can be caused by exposure to lung irritants including air pollution, cigarette smoke, dust, and chemical fumes. Air pollution can exacerbate symptoms in individuals with COPD and lead to increases in respiratory morbidity and mortality (Jiang et al. 2016). A meta-analysis on the effects of short-term air pollution and hospital admissions and mortality found exposure to air pollution was positively associated with an increased risk of hospital admission for COPD (Atkinson et al. 2014).

Communities of color or low socioeconomic status share a disproportionate burden of COPD. Environmental air pollution exposure, tobacco use, and occupational exposure to lung irritants are more common in low socioeconomic status populations making them more susceptible to developing COPD as well as experiencing exacerbations and worsened COPD-related health outcomes (Pleasants et al. 2016). Disparities in the prevalence of COPD persist even among people who have never smoked tobacco; Black women have reported the highest levels of COPD compared to Black men and White women and men in the United States (Fuller-Thomson et al. 2016). While tobacco smoke remains a leading cause of COPD, this evidence indicates community level factors, socioeconomic status, and environmental air pollutants play an important role in COPD etiology and health vulnerabilities.

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4.3 Sensitive Receptor Locations

General Description

Sensitive receptor locations are places where individuals congregate or temporarily reside who are potentially more vulnerable to adverse effects of exposure to air pollution. Sensitive receptors include schools, day-care and pre-schools, long-term care residences, prisons, and public and subsidized housing.

Indicator Measurement and Units

The type, name, and distance of sensitive receptor to the proposed project. If available, provide additional information on the number of people located at the site (i.e., student enrollment, long-term care population, prison population, etc.).

Data Sources

- Schools and long-term care residences
  - Massachusetts DPH EJ Tool (https://matracking.ehs.state.ma.us/Environmental-Data/ej-vulnerable-health/environmental-justice.html)
  - Original data from: Massachusetts Department of Elementary and Secondary Education
- Childcare or daycare facilities and preschools:
  - Google Maps (https://goo.gl/maps/Dzt71evn7PSUWJDdA).
- Prisons:
  - EJScreen (https://ejscreen.epa.gov/mapper/)
  - Original data from: Department of Homeland Security (includes federal and local government facilities)
- Public and subsidized housing:
  - EJScreen https://ejscreen.epa.gov/mapper/
  - Original data from: U.S. Department of Housing and Urban Development

Rationale

Sensitive receptors include schools, daycare facilities, elderly housing and long-term care facilities, prisons, and public and subsidized housing. These are areas where the occupants are more susceptible to the adverse effects of exposure to pollutants. Sensitive receptors are areas where higher risk people may be temporarily or permanently residing. People can be identified in a higher risk or vulnerable category to environmental pollution due to age, socioeconomic status, or underlying health conditions (U.S. EPA 2022; CARB 2022). Some of the sensitive receptors are focused on individuals having age-related vulnerability – that is, sites with concentrated populations of children or elderly individuals, such as schools, daycare or childcare centers, preschools, and long-term care residences. Public and subsidized housing and prisons are included as sensitive receptors because they often house people who are low income and people of color; socioeconomic status has been directly tied adverse health outcomes from environmental exposures, specifically air pollution.

Long-term care residences, schools, daycares, and preschools can permanently and temporarily house individuals who could be especially vulnerable to the health effects of air pollution due to their age and proximity to air emission sources. Children are a vulnerable population to pollution, and air pollution specifically, since their lungs are growing, and they breathe more than adults relative to their size (Kulkarni and Grigg 2008). Air pollution has been correlated with asthma emergency department visits, asthma hospitalizations, asthma exacerbation and increased use of medication, missed school days, cough, and mortality due to lower respiratory infections in children (Alhanti et al. 2016; Kulkarni and Grigg 2008; Ko et al. 2007; Lelieveld et al. 2018).

Long-term care facilities house older adults, who are also sensitive and vulnerable to exposure to air pollution, often due to the presence of disease and comorbidity (simultaneous presence of two or more diseases) in older adults. Ageing is a continuous process of progressive decline of the body's function leading to increased vulnerability, frailty, and sensitivity of elderly people; in this century, a major epidemiological trend is the rise of chronic diseases that affect more elderly than younger people (Simoni 2015). Studies have shown an association between long-term exposure to air pollution and premature death (Piazza 2018). In addition, older adults have been found to have an increased risk of dying after intermittent exposure to elevated levels of air pollution, suggesting that even short-term exposures to air pollution may have an impact on the health of older adults (Piazza 2018; Di et al. 2017; Simoni et al. 2015).

Prisons also house vulnerable populations, who are often people of color, low income, and struggle with mental health and other health issues. Prisoners are involuntarily confined and therefore also vulnerable to environmental pollution, contamination or other health risks within or in proximity to the prison. Public and subsidized housing developments often house higher proportions of ethnic/racial minorities, individuals in poverty, other vulnerable populations such as disabled and elderly residents, and people with pre-existing health conditions, making these populations more vulnerable to the risks of air pollution.

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4.4 Air Quality / Climate

This section describes seven air quality / climate indicators, with information provided by EPA's EJScreen tool and MassDEP.

4.4.1 $PM_{2.5}$

General Description

Particulate matter (PM) refers to a mixture of solid particles and liquid droplets in the air. PM is emitted to the atmosphere from natural sources and from man-made sources such as power plants, automobiles, construction sites, and unpaved roads (U.S. EPA 2021). Fine particles that are less than 2.5 micrometers in diameter are referred to as $PM_{2.5}$. $PM_{2.5}$ particles pose a great health risk because they can be inhaled and move into the lungs or bloodstream, causing a variety of health problems, particularly to the lungs and heart.

Indicator Measurement and Units

Annual average $PM_{2.5}$ concentration in micrograms per cubic meter ($\mu g/m^3$) for each census tract and associated statewide percentiles.

Data Source

- Data obtained from EJScreen: https://ejscreen.epa.gov/mapper/
- EJScreen obtains data from EPA's Office of Air and Radiation (OAR) fusion of model and monitor data. Most recent data is for 2018.

Rationale

PM is one of six criteria air pollutants for which EPA has established National Ambient Air Quality Standards due to its harmful impact on public health and the environment. Quantitative data on $PM_{2.5}$ levels in ambient air are publicly available and updated daily, and this pollutant is used as an indicator in many other EJ screening and mapping tools.

The links between $PM_{2.5}$ exposure and physical health are well established. Exposure to PM is associated with low birth weight in infants, exacerbation of asthma, aggravated lung disease, reduced lung function, premature death in people with heart or lung disease, development of acute and chronic bronchitis, increased susceptibility to respiratory infection, and heart attacks (Du et al. 2016; Enders et al. 2019; Guarnieri and Balmes 2014; Heo et al. 2019; Sompornrattanaphan et al. 2020). Recent research has found an association between long-term $PM_{2.5}$ exposure and depression and suggests an association with anxiety (Braithwaite et al. 2019). Increased PM levels in air are linked with increased hospital admissions and emergency room visits (Peng et al. 2022; Strosnider et al. 2018; Tian et al. 2019). The World Health

Organization (WHO) estimated that in 2016, outdoor air pollution caused 4.2 million premature deaths due to exposure to $PM_{2.5}$ (WHO 2021).

$PM_{2.5}$ exposure is higher than average for people of color, and Black, Hispanic, and Asian people in the United States (Tessum et al. 2021). People with preexisting heart or lung diseases, older adults, and children are at greater risk of adverse health impacts associated with $PM_{2.5}$ (U.S. EPA 2021). Even healthy people may experience acute respiratory health effects when exposed to increased levels of PM (Shaughnessy et al. 2015).

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4.4.2 Ozone

General Description

Ozone (O_3) occurs naturally in the upper atmosphere where it acts as a protective layer between the earth and the sun. At ground-level, ozone can be created by a chemical reaction between sunlight and other pollutants such as volatile organic compounds (VOCs) or nitrogen oxides (NOx) emitted by power plants, automobiles, and other industrial sources. Ground-level ozone is associated with increased respiratory health problems.

Indicator Measurement and Units

May through September average of daily maximum 8-hour-average ozone concentration in parts per billion by census tract and associated statewide percentile .

Data Source

- Data obtained from EJScreen: https://ejscreen.epa.gov/mapper/
- EJScreen obtains data from EPA's Office of Air and Radiation (OAR) fusion of model and monitor data. Most recent data is for 2018.

Rationale

Ozone is one of six criteria air pollutants for which EPA has established National Ambient Air Quality Standards due to its harmful impact on public health and the environment. Exposure to ozone is associated with respiratory health effects, including coughing and throat irritation, difficulty breathing, inflammation and damage in the airways, increased susceptibility to lung infections, aggravated lung diseases, increased emergency department visits, and asthma exacerbation (Guarnieri and Balmes 2014; Kim et al. 2020; Strosnider et al. 2018). Ozone may even be a cause in the onset of asthma (Guarnieri and Balmes 2014; Zu et al. 2018). Elevated ozone levels are also associated with deaths from respiratory causes (Jenner et al. 2009), and studies show long-term exposure is associated with multiple causes of mortality including cardiovascular disease, ischemic heart disease, respiratory disease, and COPD (Lim et al. 2019).

People with asthma and other lung diseases, children, and older adults are most at risk of developing health problems associated with ozone (U.S. EPA 2021). Research suggests that there is a high association between unemployment or lower occupational status and mortality or hospital admissions for ozone exposure (Bell et al. 2014). At least one study has found that mortality incidence rates decrease with increased income, and ozone reductions are more beneficial for lower-income households than higher-income households (Saari et al. 2017).

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4.4.3 Diesel Particulate Emissions

General Description

Diesel particulate matter (PM) is a mixture of particles that is emitted with the exhaust of diesel engines that often power cars, trucks, buses, ships, locomotive engines, and heavy-duty equipment. It contains a mixture of compounds, including carbon particles, metals, nitrates, and sulfates. Diesel PM is often concentrated near major roadways, ports, and railyards. Exposure to diesel PM is associated with negative health impacts such as lung cancer, cardiovascular and pulmonary disease, and irritation of the eyes, throat and eyes. In 2012, the International Agency for Research on Cancer classified diesel exhaust as a carcinogen (IARC 2014).

Indicator Measurement and Units

Diesel PM concentration in air in micrograms per cubic meter (µg/m^3) by census tract and associated statewide percentile.

Data Source

- Data obtained from EJScreen: https://ejscreen.epa.gov/mapper/
- EJScreen obtains data from the EPA AirToxScreen, 2017 (US EPA 2017)

Rationale

Diesel exhaust is comprised of a mixture of compounds and contains 40 hazardous air pollutants (HAPs) listed by EPA, many of which are known, probable, or possible carcinogens

(Clean Air Task Force 2005). Diesel PM is used as an indicator in many other EJ screening and mapping tools.

People that live or work near busy roadways, bus yards, ports, railyards, or trucking distribution centers may experience a high level of diesel PM exposure (Krivoshto et al. 2008; U.S. EPA 2002). Exposure to diesel PM can lead to worsening asthma and emphysema-related symptoms and cardiovascular effects including coronary vasoconstriction and premature death from cardiovascular disease (Krivoshto et al. 2008). Diesel exhaust can cause increases in blood pressure and other potential triggers of heart attack and stroke in healthy adults (Krishnan et al. 2013).

Children and those with existing respiratory disease, are especially susceptible to the harmful effects of PM from diesel exhaust, which can lead to increased asthma symptoms and attacks along with decreases in lung function (McCreanor et al. 2007; Wargo et al. 2002). In children living in close proximity to roadways, diesel exposure may also lead to reduced lung function (Brunekreef et al. 1997).

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4.4.4 Air Toxics Cancer Risk and Respiratory Hazard Index

General Description

Air toxics, or pollutants (HAPs), are compounds that are known to cause serious health impacts, including cancer. Air toxics can originate from a wide variety of sources including industry, transportation, and power plants. People are exposed to HAPs daily in and around their homes, at school or work, and while moving about the area. Inhaling HAPs can have adverse effects on human health.

In March 2022, EPA released the results of its 2017 Air Toxics Screening Assessment (AirToxScreen; U.S. EPA 2017). AirToxScreen helps assess which air toxics and emission source types may pose health risks and helps agencies determine which places may need further study to better understand risks. AirToxScreen characterizes cancer and noncancer health risks due to breathing air toxics based on health benchmarks which assess the health risks associated with air toxics concentrations.

Indicator Measurement and Units

Cancer Risk

Lifetime cancer risk from inhalation of air toxics, as risk per lifetime per million people (does not include diesel PM) presented as census tract statewide percentiles for air toxics cancer risk

Respiratory Hazard Index

Ratio of exposure concentration to health-based reference concentration by census tract and associated statewide percentiles for air toxics hazard index on respiratory effects

Data Source

- Data obtained from EJScreen: https://ejscreen.epa.gov/mapper/
- EJScreen obtains data from the EPA AirToxScreen, 2017

Rationale

Air toxics are pollutants that may cause cancer or other negative health impacts such as reproductive effects or birth defects. EPA regulates 188 air toxics or HAPs. Air toxics are included as an indicator in many other EJ screening and mapping tools.

People that are chronically exposed to air toxics have an increased chance of experiencing cancer or non-cancer health effects including damage to the immune, neurological, reproductive, developmental, and respiratory systems. Living near facilities that release air toxics has been linked to increased brain cancer in children (Choi et al. 2006), increased infant mortality rates (Agarwal et al. 2010), low birth weight (Gong et al. 2018), higher total mortality, and mortality form cardiovascular disease (Hendryx and Fedorko 2011). Studies have observed greater releases in low-income and disadvantaged areas (Szasz and Meuser 1997; Collins et al. 2016).

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4.4.5 Traffic Proximity and Volume

General Description

Air pollutants are found at higher concentrations near roads and highways, and over 45 million people in the United States live, work, or attend school near a major roadway or other transportation facility and may be affected by traffic-related air pollution (U.S. EPA 2014). Elevated concentrations of these pollutants such as PM, CO, NOx, ozone, and air toxics have been found to extend 500 meters from roadways (Boogaard et al. 2022). Proximity to traffic is also associated with increased exposure to noise, diesel PM, and other pollutants.

Indicator Measurement and Units

Count of vehicles per day (average annual daily traffic) at major roads within 500 meters (or nearest one beyond 500 m), divided by distance in meters, by census tract and associated statewide percentile for traffic proximity.

Data Source

- Data obtained from EJScreen: https://ejscreen.epa.gov/mapper/
- EJScreen obtains data from the U.S. Department of Transportation National Transportation Atlas Database, Highway Performance Monitoring System. Most recent year is 2019.

Rationale

Air pollutants such as PM, ultrafine particle matter, CO, NOx, ozone, and air toxics can be emitted directly from vehicles, from road dust and vehicle wear, or formed in the atmosphere due to chemical reactions with exhaust (U.S. EPA 2014). Proximity to mobile sources of air pollution can increase exposure to pollution and, in turn, increase the risk of related health impacts. Proximity to roads is associated with cardiovascular disease, reduced lung function, impaired lung development, pre-term and low–birth weight infants, childhood leukemia, diabetes, stroke, and premature death (Boogaard et al. 2022; U.S. EPA 2014). Studies show that long-term exposure to pollution from traffic is highly associated with all-cause, circulatory, ischemic heart disease, and lung cancer mortality (Boogaard et al. 2022). There is also a strong association between long-term exposure and asthma onset in both children and adults and acute lower respiratory infections in children (Boogaard et al. 2022).

Children, older adults, people with preexisting cardiopulmonary disease, and people of low socioeconomic status are at higher risk of developing health problems from air pollution near roadways (U.S. EPA 2014). In the United States, the population living near high traffic volume roads is disproportionately non-White and low-income (Rowangould 2013).

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4.4.6 Impervious Surfaces

General Description

The prevalence of impervious surfaces and tree canopy can contribute to heat island effects. Generally speaking, areas with more impervious surface tends to be warmer than average, while areas with more tree canopy cover tend to be cooler than average. Increased prevalence of impervious surfaces and relatively higher surface temperatures can increase heat-related deaths and illnesses, which can be exacerbated by air pollution.

Indicator Measurement and Units

The percent of all land covers that are identified as impervious surfaces by census tract and across the state.

Data Source

Impervious surface percent was calculated by MassDEP GIS experts for each census tract . Data and maps are available through MassDEP. This resulting land cover layers are the result of a cooperative project between MassGIS and the National Oceanic and Atmospheric Administration’s Office of Coastal Management. The original land cover dataset was derived from 2016 USDA National Agricultural Imagery Program aerial multispectral imagery.

Rationale

Heat islands and extreme surface temperatures can increase heat-related deaths and illnesses, which can be exacerbated by air pollution. A higher prevalence of impervious surfaces can lead to higher surface temperatures, which contribute to increased air pollution with a greater need for air conditioning, contributing to decreased air quality. Urban heat islands have also been associated with increased heat-related mortality. On the other hand, the presence of tree canopy with lower prevalence of impervious surfaces can mitigate heat impacts, air pollution, noise pollution and provide recreational/physical activity opportunities. Studies in Canada and the United States reported that trees removed air pollution and avoided human mortality and incidences of acute respiratory symptoms (Nowak et al. 2014; Nowak et al. 2018).

People who are Black, African American, Hispanic, or Latino are disproportionately more likely to live in areas experiencing the largest increase in heat illness or labor hours lost from extreme heat compared with other racial and ethnic groups (U.S. EPA 2021). Extreme heat exposure can exacerbate other pre-existing conditions, including those caused by air pollution, such as respiratory and cardiovascular diseases (U.S. EPA 2021).

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4.5 Nearby Regulated Facilities

General Description

Proximity to regulated facilities may degrade the surrounding environment and increase the risk that residents and people will come into contact with hazardous or toxic contaminants or substances in soil, air, and water. For example, facilities that are major sources of air pollution and that may emit VOCs, NOx, hazardous air pollutants, or other pollutants above certain thresholds must obtain a Title V Operating Permit. About 112 facilities in Massachusetts currently have these permits (Commonwealth of Massachusetts 2022). This indicator includes facilities that are major and minor sources of air pollution, as well as other facilities that have the potential or degrade the environment or emit hazardous compounds into a nearby community. This pollution burden category includes the following facility types and sources:

- Air permitted sites (DPH EJ Tool)
- Facilities reporting under the USEPA Toxics Release Inventory (TRI) program (DPH EJ Tool)
- Facilities reporting under the Toxics Use Reduction Act (TURA) (Large Quantity Toxics User) (DPH EJ Tool)
- Hazardous waste treatment, storage and/or disposal facilities (DPH EJ Tool)
- Solid waste diversion and disposal facilities (MassMapper)
- Large quantity hazardous waste generators (DPH EJ Tool)

- Wastewater treatment plants (DPH EJ Tool)
- Airports (DPH EJ Tool)
- Freight rail yards (DPH EJ Tool)
- Ports (MassMapper)

Indicator Measurement and Units

Number and location of facilities or sites within 1 or 5 miles around the proposed project.

Data Source

- MassDEP, Massachusetts DPH EJ Tool (https://matracking.ehs.state.ma.us/Environmental-Data/ej-vulnerable-health/environmental-justice.html) and MassMapper (https://maps.massgis.digital.mass.gov/MassMapper/MassMapper.html)

Rationale

Air emissions and hazardous substances from regulated facilities have the potential to move offsite and may negatively impact health or make nearby receptors more sensitive to the impacts of air pollution. For example, studies show an association between proximity to municipal solid waste sites such as landfills, dumpsites, incinerators, open burning, recycling facilities, and anaerobic digestors and adverse health effects in nearby residents including adverse birth and neonatal outcomes and increased risk of mortality, respiratory disease, and negative mental health effects (Vinti et al. 2021). Studies evaluating the health of populations near hazardous waste sites show an association between exposure and liver, breast, testis, and bladder cancers; non-Hodgkin lymphoma; asthma; low birth weight, and pre-term birth (Fazzo et al. 2017).

Studies suggest proximity to regulated sites and areas of environmental degradation may also disproportionately impact certain populations. For example, waste facilities including landfills and hazardous waste sites are more often located in areas with minorities (Martuzzi et al. 2010). Exposure to $PM_{2.5}$ from electricity generation is highest for Black and low-income people (Thind et al. 2019). Black, low-income, and people with lower educational attainment are more likely to live near TRI facilities (Mohai et al. 2009). Meng (2020) found that almost 1 in 3 public schools in Boston, MA are located within a mile of a TRI site, and nearly 1 in 3 students attends one of these schools. Schools with a high percentage of minority and economically disadvantaged children were more likely to be located near a TRI site (Meng 2020).

These indicators can be used to qualitatively assess the applicant's proximity to additional transportation hubs that are significant sources of air pollution from planes, ships, trains and associated infrastructure. Transportation hubs are a source of elevated air pollution, and proximity to transportation hubs such as airports increases exposure to air pollution and, therefore, increases risk of air pollution-related health impacts. For example, studies show that concentrations of ultrafine particulate matter, $PM_{2.5}$, black carbon, criteria pollutants, and PAHs are elevated around airports (Riley et al. 2021) and CO, NO_2, $PM_{2.5}$, and black carbon can be emitted from seaports (Steffens et al. 2017). Exposure to these pollutants can negatively impact health. Health impacts associated with proximity to airports include increased rates of premature death, pre-term births, decreased lung function, oxidative DNA damage, childhood leukemia, increased hospital admissions, and increased self-reported lung symptoms (Bendtsen et al. 2021; Riley et al. 2021).

There is evidence that emissions from transportation hubs disproportionately impact certain demographics and socioeconomic groups. For example, a study analyzing the impacts of aircraft emissions at the Hartsfield-Jackson Atlanta International Airport found that higher than average contributions of aircraft $PM_{2.5}$ were found in census tracts that had lower median household incomes, home values, and educational attainment and had a higher percentage of non-White residents (Rissman et al. 2013). Henry et al. (2019) found that in California schools near airports, low socioeconomic students were disproportionately impacted. Populations living near major rail yards with the highest cancer risks in California are disproportionately low-income or minority (Hricko et al. 2014).

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